rial, for any conclusions that may be drawn from these figures should be directly comparable and not subject to correction by the differences in the moisture contents of the several air-dried materials. The values recorded are the average of the two determinations previously reported.

	Root.	Stem.	Leaf.	Bract.	Corolla.
Ca	0.35 p. c.	0.20 p. c.	0.77 p. c.	0.63 p. c.	0.33 p. c.
Mg	0.074 p. c.	0.018 p. c.	0.13 p. c.	0.12 p. c.	0.062 p. c.
Fe	0.19 p. c.	0.050 p. c.	0.095 p. c.	0.11 p. c.	0.092 p. c.
Al	0.20 p. c.	0.049 p. c.	0.18 p. c.	0.15 p. c.	0.33 p. c.
Cl	0.30 p. c.	0.029 p. c.	0.032 p. c.	0.077 p. c.	0.017 p. c.
CO_3	0.026 p. c.	0.89 p. c.	1.45 p. c.	1.49 p. c.	1.78 p. c.
SO_4	0.15 p. c.	0.17 p. c.	0.71 p. c.	0.54 p. c.	0.19 p. c.
SiO_3	10.00 p. c.	0.87 p. c.	1.67 p. c.	4.26 p. c.	1.35 p. c.
Undetermined	0.90 p. c.	2.03 p. c.	5.53 p. c.	5.93 p. c.	3.54 p. c.

THALLIUM POISONING IN MIGRATORY BIRDS.

BY JUSTUS C. WARD.*

Since its introduction into the United States about 1920, thallium has been used with marked success in the control of injurious rodents. In areas where other poisons have failed to reduce the damage caused to ranchers and orchardists by these pests, thallium has proved highly effective. Thallium-poisoned grain is tasteless and the action of the poison is slow and insidious. There are no prompt warning features to limit acceptance, and rodents in most cases eat the entire bait-spots. In short, thallium is useful as a follow-up poison, but it is not a specific, that is to say, it will kill anything that eats it. Of recent years, thallium has been condemned as being responsible for losses of valuable species of birds and mammals.

A former publication (1) had to do with one phase of this problem, and it was definitely proved that thallium was wrongly blamed for sheep losses in the San Luis Valley in Colorado. The present investigation arose from a regrettable loss of wild geese around Yosemite Lake, California, found by investigators in that state to have been caused by thallium. The geese met their death from eating barley poisoned with thallium, which had been exposed by private individuals for a purpose not yet known.

References found in the literature (3) (4) relative to the toxicity of thallium to ducks or geese give no definite information relative to the toxicity to these birds of baits put out for Ground-Squirrels. The present investigations were undertaken to obtain this information. They were divided into: (1) Determination of the minimum lethal doses of thallium by intraperitoneal injection and by feeding; (2) observation of typical thallium death; (3) post-mortem observations; and (4) spectroscopic and chemical analyses.

Since no Canada geese were obtainable, female mallard ducks were used in all tests.

I. M. L. D. Studies: A. Intraperitoneal Injections.

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TABLE I.—MINIMUM LETHAL DOSE OF THALLIUM (AS SULPHATE)—IP—WILD DUCKS.

Duck No.		Dose.	Results.
1st Series	1	100 mg./Kg.	Died over night.
	2	75 mg./Kg.	Died over night.
	3	50 mg./Kg.	Died over night.
	4	35 mg./Kg.	Died in 63 hours.
	5	25 mg./Kg.	Survived.
	6	15 mg./Kg.	Died in 63 hours.
2nd Series	7	20 mg./Kg.	Survived.
	8	15 mg./Kg.	Survived.
	9	10 mg./Kg.	Survived.
	10	7.5 mg./Kg.	Survived.
	11	5 mg./Kg.	Survived.
3rd Series	12	35 mg./Kg.	Killed for analysis 48 hours.
	13	35 mg./Kg.	Died in 13 days.
	14	25 mg./Kg.	Killed for analysis 44 hours.
	15	25 mg./Kg.	Died in 13 days.

From this table it is seen that for intraperitoneal injection the M. L. D. is about 25 mg./Kg.

In about fifteen days ducks Nos. 5, 7, 8 developed a loss of feathers, which was confined completely to the small of the back just above the uropygial gland.

Ducks 9, 10 and 11 failed to show any unfavorable symptoms of any kind.

B. Feeding Tests.—To determine the acceptance of poisoned barley by ducks two separate tests were conducted. In the first of these, three ducks were caged together and fed 200 Gm. of the California thallium-poisoned barley, which contained 1800 mg. of thallium (as sulphate). There was no other feed in the cage. The three ducks had eaten only 45 Gm. of the feed in two days. At the end of that time two of them (Nos. 10 and 11) were dead. No. 9, the surviving duck, ate only 27 Gm. more feed in the period of nine days that elapsed before death. The three ducks ate a total of 648 mg. of thallium.

In the second acceptance test, duck No. 21 (Fig. 5) was given the choice of clean cracked corn or poisoned barley. A total of only 6 Gm. (54 mg. of thallium) of the poisoned feed was eaten in 12 days. Needing the bird for chemical analysis, on the thirteenth day, a total of 15 Gm. (135 mg. of thallium) more poisoned barley was forced down its throat. It was found dead on the second morning.

These tests indicate that even though other food is available, poisoned barley is slowly accepted by migratory birds in quantities sufficient to kill.

An additional test to determine more definitely the M. L. D. of thallium when fed to ducks in the form of the California poisoned barley gave the results shown in Table II. To be sure of the dose ingested these ducks were fed by force.

TABLE II.—M. L. D. OF THALLIUM (AS SULPHATE)—FED—WILD DUCKS.

Duck No.	Dose.	Results.
16	75 mg./Kg.	Dead over night.
17	50 mg./Kg.	Died in 12 days.
18	35 mg./Kg.	Survived.

These figures, together with those from the earlier feeding tests, indicate the M. L. D. of thallium for ducks to be about 50 mg./Kg. for this method of administration.

No. 18 also showed loss of feathers in the rump region at the end of three weeks.

II. Observation of Typical Thallium Death in Ducks.—Resembling closely symptoms in sheep, which have been described (1), thallium causes a marked gasping for breath because of the mucous clogging of the nasal passages, a profuse and green-colored diarrhea, a loss of accommodation, wabbly gait, and extreme

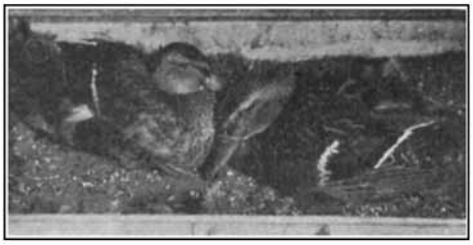

Fig. 1.—Ducks 13 and 15, ten days after injection.

Fig. 2.—Duck 7, twenty-five days after 20 mg./Kg. IP, showing area of depilation.

Fig. 3.—Duck 7, seventy-five days after 20 mg./Kg. IP.

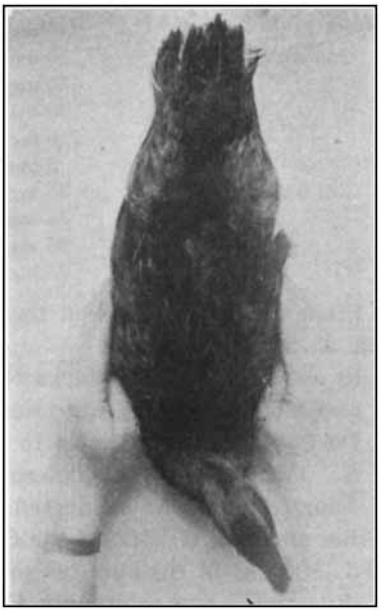

Fig. 4.—Duck 5, five months after 25 mg./Kg. IP, showing new feather growth.

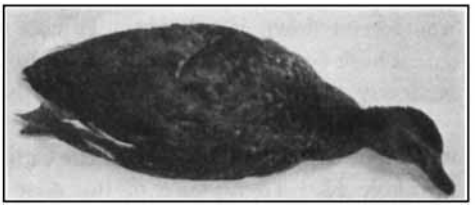

Fig. 5.—Duck 21, one day before death.

Observation of Typical Thallium Poisoning in Ducks.

exhaustion characterized by prostration on the floor of the cage, wings drooped, feet and legs fully extended, head and neck limp. This position is characteristic of coma, and with doses close to the M. L. D. it may persist for a couple of days before death. As death approaches the bird goes into intermittent asphyxial

spasms. Death is due to respiratory failure, and occurs within two hours after the spasms begin.

III. Post-mortem Observation.—The entire gastro-intestinal tract was plugged with a thick yellowish mucous.

Irritation and ulceration were present in the small intestine.

The gizzard was empty, but the lining was colored a light yellow.

The liver was enlarged and apparently degenerated (gross appearance of fatty degeneration similar to *P*), the tissue soft and filled with spots, and the gall bladder was distended with viscid fluid.

The kidneys were somewhat enlarged and of a dark purple color.

The lungs, heart, genital organs and other structures were normal, although excess fluid was usually found in the pericardium.

IV. Spectroscopic and Chemical Analyses.—In order to determine the distribution of thallium in the various parts of the bird these studies were conducted:

TABLE III.—ANALYTICAL RESULTS—THALLIUM IN DUCKS.

Duck No.	Total Tl ingested.	Time to death.	Organ analysed.	Total Tl found.	Spectroscope.
9	.....	11 days	Liver and kidneys	4.5 mg.	+
			GI tract	6.0 mg.	+
			Muscular tissue	4.0 mg.	+
10	.....	30 hours	Liver and kidneys	3.5 mg.	+
12	31.8 mg.	30 hours	Liver and kidneys	2.0 mg.	++
			GI tract	Trace	Faint
			Muscular tissue	Trace	Faint
			Blood, heart, lungs	.....	None
			Bones	.....	None
13	21.7 mg.	13 days	Liver and kidneys	1.9 mg.	+
14	22.8 mg.	44 hours	Liver and kidneys	2.6 mg.	+
			GI tract	2.0 mg.	+
			Muscle	Trace	Faint
			Blood, heart, lungs	2.0 mg.	+
			Bones	None	?
15	27.8 mg.	13 days	Liver and kidneys	2.0 mg.	+
17	37.5 mg.	12 days	Liver and kidneys	None	+
			Heart and lungs	None	+
			GI tract	None	Faint
			Muscle	None	?
			Bones	None	None

In the chemical examinations, the method given by G. R. Lynch and J. M. S. Scovell for analysis of thallium in viscera (2) was used, it being found to be the one most free from objectionable features of any tried in this laboratory.

CONCLUSIONS.

1. The minimum lethal dose of thallium (as sulphate) to ducks when injected intraperitoneally is about 25 mg./Kg. When fed as poisoned barley it is about 50 mg./Kg. (The M. L. D. of phosphorus to ducks is quite variable, but death has occurred from 1 mg./Kg.)

2. Ducks will accept poisoned barley in lethal quantities.

3. Sublethal doses will cause loss of feathers in the area on the back just above the uropygial gland.

4. Thallium may be isolated from various structures of the body even when death is delayed for thirteen days.

5. Spectroscopic methods of analysis are much more sensitive than chemical ones.

6. Close supervision should be kept of all thallium used in rodent poisoning, and it should be employed only by trained men.

June 23, 1931.

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A STUDY OF THE BORNTRAEGER COLOR REACTION AND THERAPEUTIC ACTIVITY OF CASCARA SAGRADA.*

BY S. W. MORRISON.[1]

There is no satisfactory method to standardize or assay cascara preparations. As a consequence there is some variation in the therapeutic activity of the extracts on the market.

Considerable work has been done by Eaton (1), Fuller (2) and others in an effort to isolate the active ingredients, and to establish a reliable means of comparing the relative activity of different cascara products.

The Borntraeger reaction has been advocated as a means of standardizing fluidextract of cascara and has been utilized by Peter Valaer (3) and others (4) to make quantitative tests for cascara.

The Borntraeger test consists in extracting the ether-soluble constituents from the cascara preparation and developing a red color in the yellow ether solution by the addition of ammonia water. The depth of the colors is measured in a Lovibond tintometer against a suitable standard color.

Various solvents and methods have been used by Nitardy (5), and Milford Harris and Davy (6) to extract the active portion from the cascara bark. Attempts have also been made to obtain a potent preparation of cascara free from bitter taste and griping action.

It has been found also that cascara products vary greatly in the degree and shade of color produced with the Borntraeger test.

The object of the present investigation was to determine if the color tests for cascara sagrada parallel its therapeutic activity.

EXPERIMENT I.

Two hundred and fifty grams of ground cascara bark were extracted in a percolator with boiling water as directed in the U. S. P. X. The percolator was surrounded by a hot water jacket to retain the heat during the extraction.

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